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THE PECAN NUT CASE-BEARER[1]

By John B. Gill, *Associate Entomologist, Fruit Insect Investigations, Bureau of Entomology*

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INTRODUCTION

For a number of years the Bureau of Entomology maintained a field laboratory in the southeastern portion of the pecan belt at Monticello, Fla., for the investigation of the biology and habits of pecan insects and to determine the most effective control measures for the more important species under orchard conditions. The results of the greater portion of these investigations have been published (*4, 5*),[2] but as a part of this work this bulletin brings together the results of a rather detailed study of the life history of the pecan nut case-bearer (*Acrobasis hebescella* Hulst), an insect which is now recognized as a most formidable enemy of the pecan because of its nut-feeding habits.

HISTORY

The pecan nut case-bearer was first described by Hulst (*7*) in 1890 under the name of *Acrobasis hebescella.* In 1893 Ragonot (*9*) treated this species, and in 1901 it was listed and figured by Hampson (*6*), but the figure given is a poor reproduction of the moth. Dyar's "List of North American Lepidoptera" (*1*) contains this species, the distribution being given as New Jersey, Texas, Illinois, and Wisconsin. In 1902 E. P. Stiles (*11*) gave an account of injury in west-central Texas caused by what he called the pecan huskworm, but doubtless due to *Acrobasis hebescella* and a closely related species, *A. caryivorella* Rag.

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[1] *Acrobasis hebescella* Hulst; order *Lepidoptera,* family Pyralidae.

[2] Reference is made by number (italic) to "Literature Cited," p. 12.

Sanderson (*10*) reported serious injury to the pecan crop by *A. caryae* in 1903, but it appears to the writer that the greater portion of the damage, if not all, should have been accredited to the species of Acrobasis discussed in this bulletin and to *A. caryivorella.* Dyar in 1908 (*2*), in a paper on the species of Acrobasis, includes this insect. In 1914 the writer (*3*) made a brief mention of this species in an article on the pecan leaf case-bearer (*Acrobasis nebulella* Riley), and in Farmers' Bulletin 843 (*4*), appearing in 1917, it is treated at length. The following year Turner (*12*) and Matz (*8*) gave general accounts of the insect.

DISTRIBUTION

Hulst (*7*), in his original description of *Acrobasis hebescella,* gave New Jersey and Texas as its habitat; Dyar (*1*) listed it from New Jersey, Texas, Illinois, and Wisconsin, and in an article appearing in 1908 (*2*) mentioned Brownwood, Tex., and East River, Conn., as localities in which it has been collected; and Turner (*12*) reported it from Thomasville, Ga., and Cairo, Ga. In the United States National Museum collection there are specimens from Brownwood, Tex.; Goodman, Miss.; Bon Ami, La.; and Monticello, Fla. Besides the localities mentioned, the records of the writer show that this species also occurs at Waukeenah, Fla.; Baconton, Dewitt, Putney, and Moultrie, Ga.; Mobile and Fowl River, Ala.; Ocean Springs and Pecan, Miss.; Keithville, La.; and Marshall, Victoria, and Bend, Tex.

The pecan nut case-bearer, along with another nut-feeding species of Acrobasis, *A. caryivorella* Rag., is rather generally distributed in the pecan-growing sections of the Southwest, especially in Texas, where it is reported annually as causing much damage. In the Southeast, however, it has been recorded only from scattered localities in Florida, Georgia, Alabama, Mississippi, and Louisiana. For the last 9 or 10 years this insect has been causing considerable loss to pecan growers in the vicinity of Monticello, Fla., and Thomasville, Ga., and during 1922 it was reported for the first time as occurring in injurious numbers in the large commercial orchards in the Albany, Ga., district, which is at present rated as the most important section for the production of cultivated pecan nuts. In 1923 and 1924 the insect caused very heavy damage in the large orchards at Baconton, Dewitt, Putney, and Albany, all in this district. This species appears to be gradually extending its range of destructiveness, and sooner or later it will probably prove a most formidable pest throughout the greater portion of the pecan belt.

FOOD PLANTS

The only food plant on which this insect has been found by the writer is the pecan (*Hicoria pecan*), but it is to be supposed that it subsists also on other species of the genus Hicoria. In literature oak and pecan are given as food plants. Dyar (*2*) states that six specimens from Brownwood, Tex., were bred at the insectary of the U. S. Department of Agriculture from larvæ on pecan mining into the young buds. In his original description Hulst (*7*) has the following statement:

> A specimen from New Jersey received by Prof. J. B. Smith, has on it a label marked "on oak, Jersey pines, June." The pin is thrust through an oval close cocoon which was undoubtedly made at or under the surface of the ground.

He further states:

> I have myself found the larval cases of a Phycitid in southern New Jersey on a large-leaved oak, which may be the cases of this species. They were horn-like, much resembling those of *indigenella*. The larva turned over the edge of the large leaf binding the edges, and forming a habitation large enough to move about freely within. The case itself was fastened within with threads of silk.

The habitat given by Hulst is New Jersey and Texas, but there is no mention of the food plant for the material from Texas, which was probably taken on the pecan. In the writer's opinion, the record of the New Jersey specimen "from oak" is very doubtful, because the description of the cocoon and the manner of pupation do not coincide with the facts regarding *Acrobasis hebescella* as determined in an extensive study of this species.

CHARACTER OF INJURY

The larvæ of the pecan nut case-bearer may attack either the tender shoots or the immature nuts. The larvæ that pass the winter in hibernacula around the buds cause damage in early spring by attacking the tender shoots, in which they tunnel and eat out the interior, leaving the outside intact. Many of the attacked shoots wilt and turn brown, and others are broken off by the winds (Pl. IV). Such injury is not very serious, compared with the damage caused by the first and second brood larvæ, which confine their attacks to young green nuts.

During May the first-brood larvæ make their appearance and bore into the recently set nuts. At the point of attack pellets of frass or borings are cast out (Pl. II) and held together by means of fine silken threads that form a short silk-lined tube. Nuts injured by this insect always show the characteristic mass of frass protruding from the place where the larvæ gained entrance, which is invariably in the side of the nut near the basal end. The larvæ of the second generation attack the nuts in the same manner as those of the first generation, but the damage to the crop is not so extensive because of the size of the nuts at the time of attack (Pl. III). Early in the season a single larva may destroy several nuts before attaining full growth, while later in the season one or two nuts seem to be sufficient for its subsistence. The writer's observations show that by far the greatest damage to the nut crop is inflicted by the larvæ of the first generation.

The larvæ of the third generation, which make their appearance in the late summer, usually feed very little. They seem to prefer the shucks or hulls, in which they gnaw only through the surface, forming small, narrow, elongated tunnels of frass particles of a rather delicate or flimsy texture. Such injury does not interfere with the normal development of the nuts. Some of these larvæ also feed slightly on the leaf petioles and succulent shoots, but the damage thus caused is insignificant. When the larvæ of this generation seek hibernation quarters they are usually a little less than one-tenth of an inch long.

DESCRIPTION

EGG

The egg (Pl. I, A) is elliptical, convex above and flattened below, with the surface finely wrinkled. When first deposited the egg is greenish white, and as incubation advances it takes on a reddish tinge. The eggs average 0.56 millimeter in length by 0.34 millimeter in width. The moths deposit their eggs singly on the calyx end of the nut or on the side of the nut under the calyx lobes.

LARVA

The larva (Pl. I, B at right, and D) is nearly cylindrical, tapering slightly toward each end, but more posteriorly than anteriorly. Eight full-grown larvæ when extended averaged 14.59 millimeters in length by 2.08 millimeters in greatest width. The head and mouth parts are dark brown, and the prothoracic shield is pale brown, bisected by a rather inconspicuous faint whitish area. The general color of the body is dirty olive green, darker dorsally and laterally than ventrally. The body is sparsely covered with fine whitish hairs, the skin being quite wrinkled, especially in the thoracic region. The thoracic legs are about the same color as the ventral part of the body, and each terminates in a single brown claw. There are five pairs of prolegs and the anal pair is about twice as long as the others.

PUPA

The pupa (Pl. I, B, at left) is of the usual form and without striking markings. When first formed it has a decided olive-green cast, but with age it changes to a light brown. The abdominal segments are finely punctate, the anterior portion of the last segment having a dark brown transverse band dorsally. The anal extremity is armed with a short, sharp brownish tooth, directed nearly at right angles to the body axis, and four slender light-brown hooked spines, which arise from the lower part of the tip of the last segment and project forward. The size of the pupa is decidedly variable, the average measurements for six individuals being 8.1 millimeters by 2.2 millimeters. The pupa is formed inside the attacked shoot for the spring brood (Pl. IV), and within the infested nut for the first and second broods (Pl. I, E). Upon issuance of the moth the pupal skin is not extended.

ADULT (Pl. I, C)

The pecan nut case-bearer was first described in 1890 by Hulst (7) under the name *Acrobasis hebescella*. The original description is as follows:

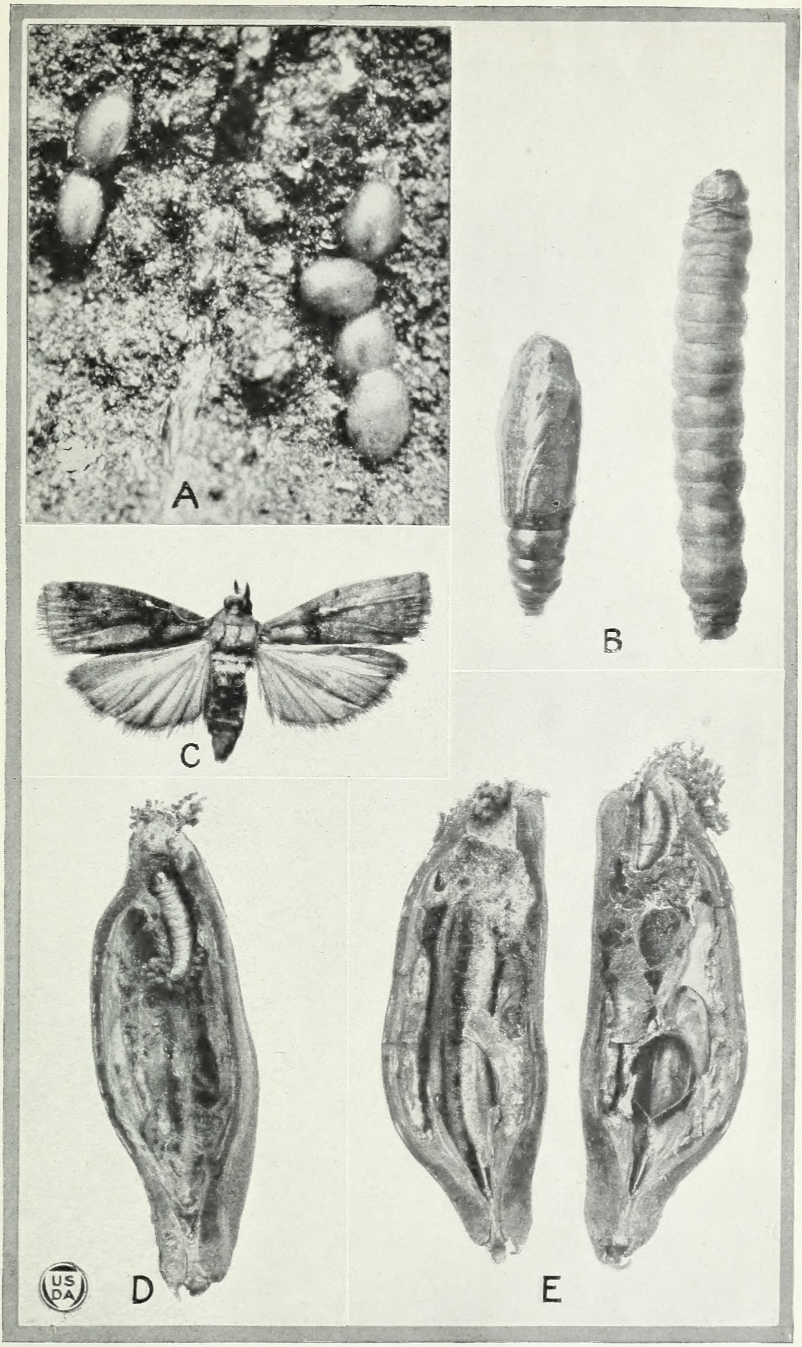
> Expands 18–20 mm. Labial palpi blackish gray. Head ochreous fuscous, thorax dark fuscous. Abdomen ochreous gray, annulate with fuscous. Fore wings short, very broad, strongly arched on costa and inner margin, ochreous fuscous, quite dark; lines indistinct, basal hardly discernible, faintly gray, edged outwardly with black at costa; scale ridge black, short; outer line dentate, shown by black border lines on ground color; discal spots quite distinct, confluent. Hind wings dark even fuscous.

The measurements of moths bred from pecans varied from 14.5 to 19 millimeters across the expanded wings.

SEASONAL HISTORY AND HABITS

All records given for the various stages of the pecan nut case-bearer were obtained at Monticello, Fla. In the rearing work pertaining to this insect glass jars were used as cages, which were kept in an open-air insectary.

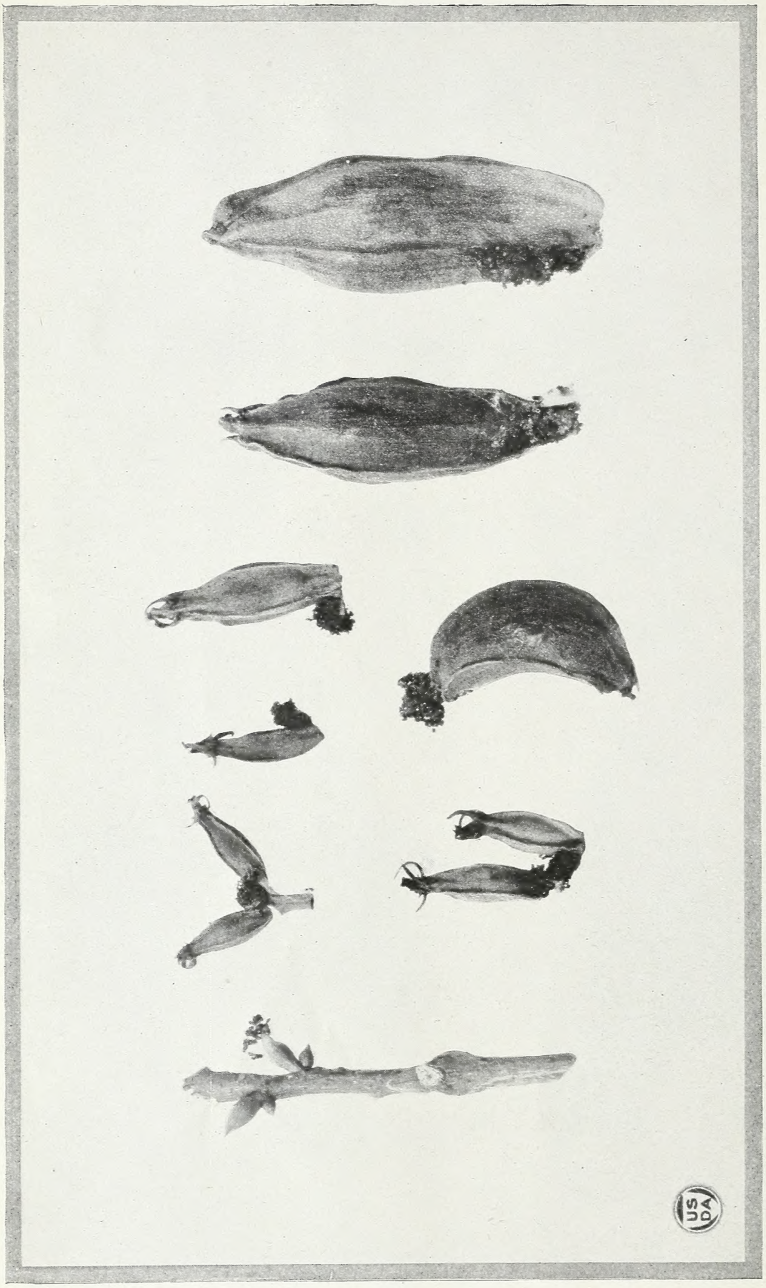
In the discussion of the life history of this species, a "generation" is considered to begin with the egg stage and to end with the adult or



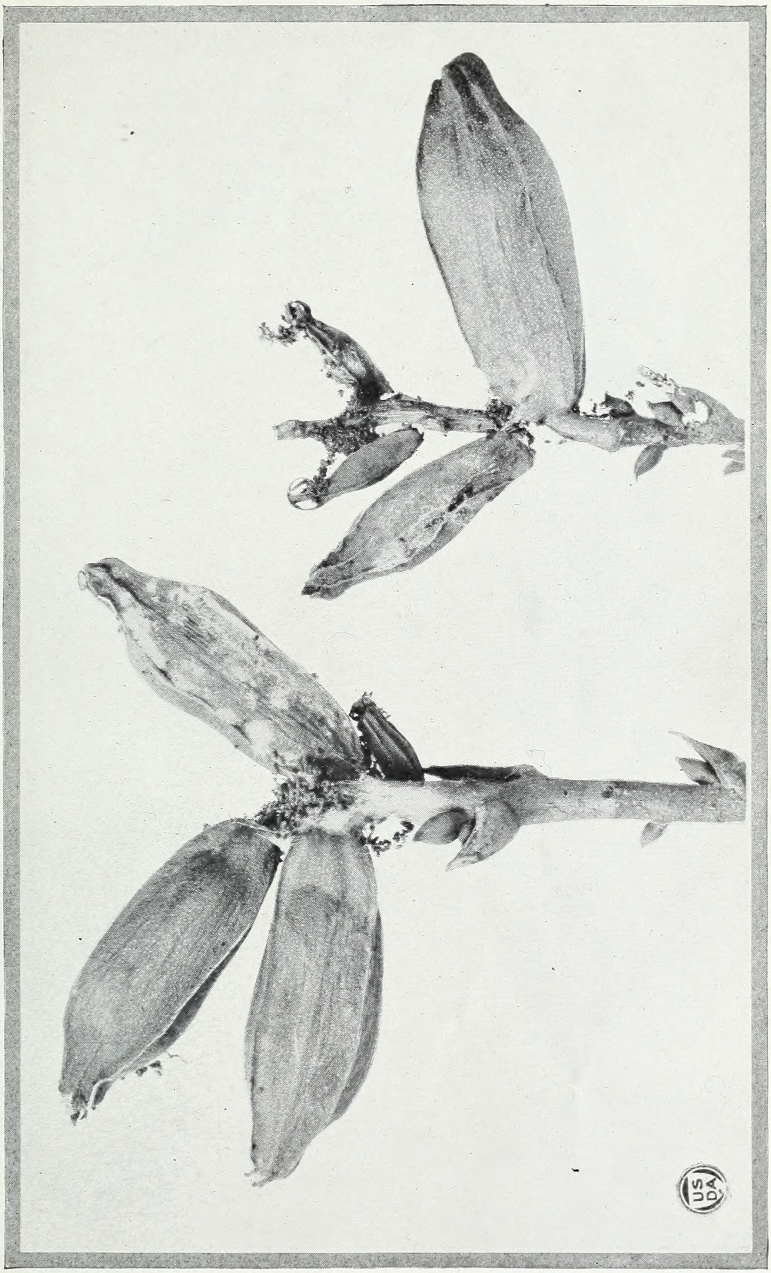
THE PECAN NUT CASE-BEARER

A, Eggs on nut. Greatly enlarged. *B*, Pupa at left larva at right. Enlarged. *C*, Adult, or moth. Enlarged. *D*, Immature pecan nut infested by larva. Slightly enlarged. *E*, Infested pecan nut showing place of pupation. Slightly enlarged

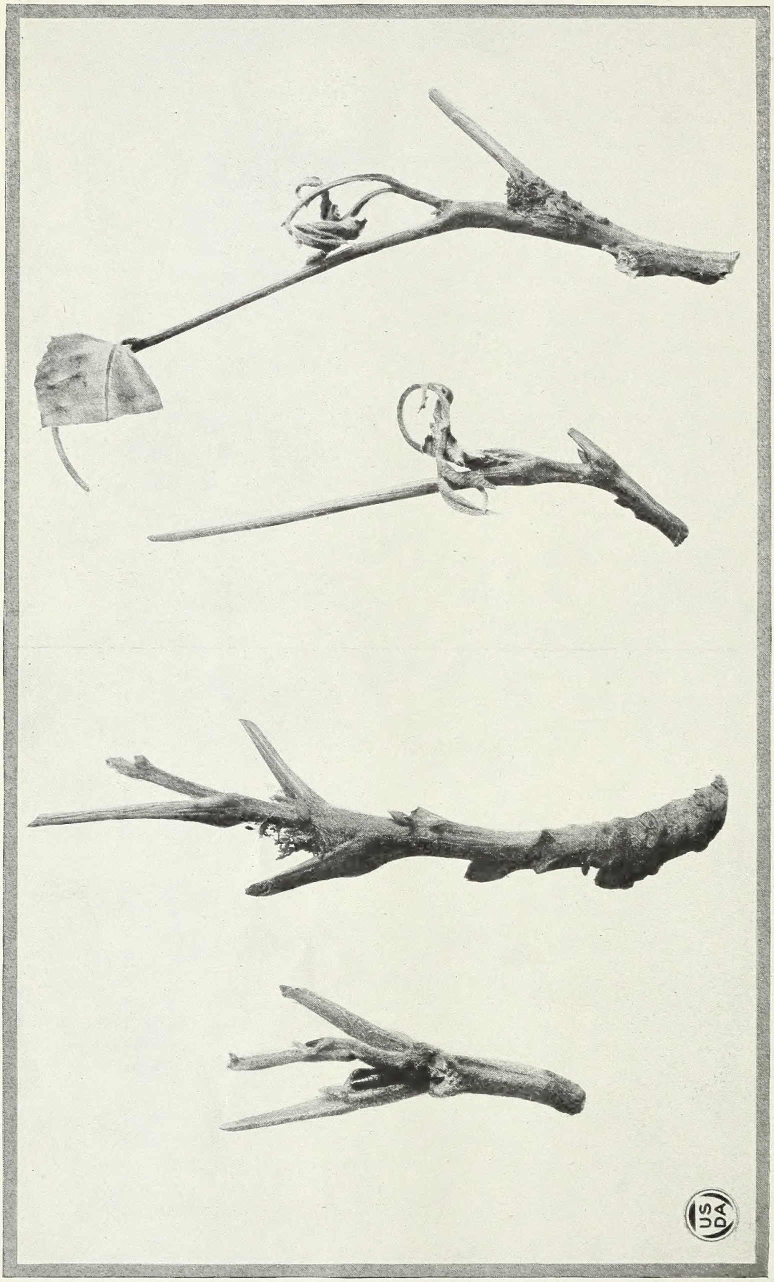
PLATE II



Immature Pecan Nuts, Showing Injury. Natural Size.



CLUSTERS OF INFESTED PECAN NUTS. NATURAL SIZE



PECAN SHOOTS, SHOWING INFESTATION BY LARVÆ IN THE SPRING. REDUCED moth stage. The term "brood" is used in speaking collectively of the individuals of any stage of a particular generation, as egg, larva, pupa, or adult. The overwintering larvæ, after transforming in the spring to pupæ and in turn to adults are referred to as "spring-brood pupæ" and "spring-brood moths." Although the spring-brood pupæ and moths are the first to make their appearance during the growing season, they are not designated as first-brood pupæ and first-brood moths, but these terms are reserved for the pupæ and moths of the next succeeding generation.

ADULT AND EGG STAGES

TIME OF EMERGENCE OF THE SPRING-BROOD MOTHS

From material under observation during the season of 1916 it was determined that spring-brood moths emerged from May 7 to May 23, and in 1917 the period of emergence was May 2 to May 17. Moths in the pecan orchard evidently came forth about the same time as those in rearing cages, a fact which was determined by numerous field observations. There is, however, one record of collecting an empty pupal skin in the field as early as May 1, 1917, indicating that this particular individual emerged earlier than the first insectary rearing. The dates of issuance of 60 individuals are shown in Table 1.

TABLE 1.—*Time of emergence of spring-brood moths of the pecan nut case-bearer, Monticello, Fla., 1916 and 1917*

1916				1917			
Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths	Date of emergence	Number of moths
May 7	1	May 16	5	May 2	1	May 12	2
8	1	17	5	3	5	14	1
10	1	18	3	4	3	16	3
11	2	19	3	5	1	17	3
12	1	20	1	7	1		
13	5	23	1	10	4	Total	24
14	1						
15	6	Total	36				

TIMES OF EMERGENCE OF FIRST AND SECOND BROOD MOTHS

Records on the times of emergence of first and second brood moths are given in Table 2 for 1914, 1915, 1916, and 1917.

From material under observation during the season of 1914, it was determined that first-brood moths emerged from June 11 to July 2, covering a period of 22 days. The maximum emergence occurred on June 23, when 15 moths came forth. The second-brood moths began to appear on July 23 and continued emerging until August 26, a period of 35 days for all individuals under observation. Probably the times of emergence of both the first and second brood moths varied somewhat from the dates based on reared specimens, but no doubt the data given closely approximate the actual times of emergence under natural conditions.

The records for 1915 show that the first-brood moths emerged from June 18 to July 15, the maximum emergence of 13 individuals occurring on June 24 and emergence for all moths extending over a period of 28 days. The earliest record of emergence for the second-brood moths occurred August 2 and emergence continued until August 31, a period of 30 days.

The emergence of the first-brood moths for 1916 began June 17 and lasted until July 16, covering a 30-day period. For the second-brood moths emergence took place from August 3 to August 30, a period of 28 days.

For 1917 the first-brood moths were found to emerge from June 13 to July 12, covering a period of 30 days. The greatest number to appear on a single day was 16 on June 29, while June 23 to July 2 marked the period of maximum emergence. The second-brood moths emerged from August 2 to August 30, a 29-day period for emergence.

TABLE 2.—*Times of emergence of the first and second brood moths of the pecan nut case-bearer, Monticello, Fla., 1914, 1915, 1916, and 1917*

First brood					Second brood				
Date	1914	1915	1916	1917	Date	1914	1915	1916	1917
	Number	*Number*	*Number*	*Number*		*Number*	*Number*	*Number*	*Number*
June 11	2				July 23	1			
12	2				24	3			
13	1			1	25	4			
14				6	26	4			
15	5			1	27	4			
16	5			1	28	9			
17	2		1	1	29	5			
18	2	2	4	2	30	9			
19	14		2	3	31	5			
20	6	2	4	1	Aug. 1	3			
21	8	2		4	2	4	1		1
22	7	4	3	3	3	9	1	1	
23	15	2	5	10	4	10	1	1	
24	12	13	5	12	5	6	2		
25	10	10	2	6	6	1	2		
26	5	5	8	14	7	6	6	1	
27	8	5	5	6	8	8		1	2
28	2	4	6	9	9	1	11		
29	2	3	3	16	10	8	7		1
30	1	2	7	5	11	10	5	1	1
July 1	1	1	6	7	12	12	10	3	
2	2	1	10	14	13	6	6	2	3
3		2	8	1	14	4	4		3
4		4	9	4	15	9	3	1	1
5		2	2	1	16	1	1	1	
6			3	3	17	5	7	3	1
7		1	1	4	18	4	3	6	1
8			2		19	4	9	5	1
9		2	1	2	20	8	8	3	
10					21		5	2	1
11			1	3	22		7	1	1
12				1	23		4	2	3
13		1	1		24	2	4	1	1
14					25		3		1
15		2			26	1	3	2	2
16			1		27		1	2	2
					28		1	2	2
					29				1
					30			1	1
					31		1		
Total	112	70	100	141	Total	166	116	42	30

LENGTH OF LIFE OF MOTHS

The length of life of moths varied from 2 to 15 days, the average for those under observation being about 6 days. The data bearing on this phase of the life history are insufficient to make any generalization, as only a few observations were made to determine this point.

OVIPOSITION AND LENGTH OF INCUBATION PERIOD

It was very difficult to get moths to oviposit in confinement. From material under observation it was determined that a period of from 2 to 7 days elapsed from the time of emergence to the time of first oviposition. The moths confined in cages usually deposited all eggs within a period of 3 days. In confinement moths deposited eggs indiscriminately upon the nuts, leaf petioles, foliage, and occasionally on the sides of the glass breeding jars. It seems that under natural conditions egg deposition invariably takes place on the nuts at the calyx or on the side immediately under the calyx lobes.

As is shown in Table 3, the average length of the period of incubation of 56 first-brood eggs was found to be 9.48 days, the maximum being 10 and the minimum 7.

Table 3.—*Length of incubation period of first-brood eggs of the pecan nut case-bearer, Monticello, Fla., 1917*

Number of eggs from which larvæ emerged	Date of oviposition	Date of hatching	Length of incubation period
			Days
29	May 11	May 21	10
26	13	22	9
1	15	22	7

The length of the incubation period for second-brood eggs is given in Table 4.

Table 4.—*Length of incubation period of second-brood eggs of the pecan nut case-bearer, Monticello, Fla., 1916 and 1917*

1916				1917			
Number of eggs from which larvæ emerged	Date of oviposition	Date of hatching	Length of incubation period	Number of eggs from which larvæ emerged	Date of oviposition	Date of hatching	Length of incubation period
			Days				*Days*
11	June 26	July 1	5	41	July 1	July 7	6
3	do	July 2	6	14	do	July 8	7
4	June 27	July 3	6	6	July 5	July 10	5
1	June 28	July 4	6	45	do	July 11	6
8	July 3	July 8	5	12	do	July 12	7
1	do	July 10	7	2	July 6	do	6
8	July 14	July 18	4	3	do	July 13	7
9	do	July 19	5	13	July 7	do	6
2	do	July 20	6				
Average for 47 individuals			5.09	Average for 136 individuals			6.17

Observations on a limited number of third-brood eggs hatching in August showed that the period of incubation ranged from 4 to 6 days, the average being 4.95 days.

LARVA STAGE

EMERGENCE OF LARVÆ FROM HIBERNATION

The overwintering larvæ become active and leave their winter cases (hibernacula) during the latter part of March or the first part of April, at which time the buds on pecan trees begin to open. After feeding slightly upon the unfolding buds, these spring-brood larvæ migrate to the rapidly growing succulent shoots, in which they feed by tunneling out the interior, keeping the burrows open by casting out the frass pellets from the hole where the initial attack was made (Pl. IV). It has been determined from field observations that the larvæ usually begin to attack the pecan shoots during the second week in April, and after feeding in this manner for two weeks or more the larvæ transform to pupæ within their burrows. During 1916 the spring-brood larvæ that were under observation pupated from April 24 to May 12, and in 1917 from April 19 to May 1. Records show, however, that a few larvæ can be found on pecan trees, especially the Stuart variety, as late as the second week in May.

FIRST-BROOD LARVÆ

The length of larval life for the first brood ranges from 22 to 29 days, the average being about 26 days. The maximum hatching of first-brood larvæ occurs during the third week in May, but the period of hatching is quite extended.

SECOND-BROOD LARVÆ

The majority of the second-brood eggs hatch during the last week in June and the first 10 days of July, but the hatching for all eggs of this brood extends over a long period. The average length of the larva stage for the second brood was found to be 25.27 days.

THIRD-BROOD LARVÆ

The hatching of third-brood larvæ begins about the middle of August and continues until the first part of September. The latest hatching of third-brood larvæ in rearing cages occurred on September 3, but under natural conditions it is likely that larvæ hatch over a longer period. The third-brood larvæ feed very sparingly for three or four weeks and then go into hibernation by constructing hibernacula, which are attached to the buds. Although the larvæ feed for several weeks, they do not attain a size greater than one-tenth of an inch. In rearing work it has been observed that the larvæ are very prone to construct their hibernacula prematurely when the food plant in breeding cages is not kept in the best of condition. The larvæ remain in their hibernacula throughout the winter, and with the advent of spring they become active just as the buds on the pecan trees are unfolding.

PUPA STAGE

PLACE OF PUPATION OF THE OVERWINTERING LARVÆ

The spring-brood pupæ are formed within the shoots in which the larvæ complete their growth. Near the mouth of its burrow the full-grown larva prepares out of particles of frass and excrement a flimsy silken-lined cell or cocoon, where its transformation to the pupa stage occurs (Pl. IV).

TIME OF PUPATION OF OVERWINTERING LARVÆ AND LENGTH OF SPRING-BROOD PUPAL PERIOD

Investigations show that the time of pupation of the overwintering larvæ is variable. Records for 1916 give April 24 as the earliest date of pupation, and the latest as May 12; while for 1917 pupæ were forming in rearing cages from April 19 to May 1. During the season of 1917 overwintering larvæ were observed in the field after May 1, showing that insectary records do not actually indicate the complete period at which transformation to pupæ occurs. Before making any generalization on the time of pupation, more extensive data are desirable, as observations have been confined to a limited number of individuals.

During 1916 and 1917 the length of the pupal period of the spring brood was determined for 19 individuals, as shown in Table 5:

Table 5.—*Length of pupal period of spring-brood pupæ of the pecan nut case-bearer, Monticello, Fla., 1916 and 1917*

1916				1917			
Number of individuals	Date of pupation	Date of emergence	Days as pupa	Number of individuals	Date of pupation	Date of emergence	Days as pupa
1	Apr. 24	May 11	17	1	Apr. 19	May 2	13
1	Apr. 28	May 13	15	1	Apr. 20	May 3	13
1	May 2	May 14	12	1	Apr. 28	May 14	16
1	May4	May 15	11	1	do	May 16	18
1	May 5	May 16	11	1	Apr. 29	May 17	18
2	May 6	May 17	11	1	Apr. 30	do	17
2	May 7	May 18	11	1	May 1	May 16	15
1	do	May 19	12				
1	May 8	do	11				
1	May 12	May 23	11				
Average for 12 individuals			12	Average for 7 individuals			15.85

TIME OF PUPATION AND LENGTH OF PUPAL PERIOD OF THE FIRST AND SECOND BROOD PUPÆ

Of the first-brood larvæ under observation that transformed to pupæ during 1914 the first pupated June 9, and during 1916 and 1917 the first pupæ appeared June 5 and June 2, respectively. Pupation continued in 1916 until June 29 and in 1917 until July 2, while in 1914 the last pupa for insectary material was recorded on June 19. It should be stated, however, that larvæ under natural conditions were probably pupating for a week or 10 days later than pupation records for 1914 indicate, as it was determined on June 20 from field-collected material that only 85 per cent of the larvæ had pupated. These records are given in Table 6.

The second-brood larvæ transform to pupæ during the latter half of July and the greater part of August. The time of pupation for a number of individuals of the second brood is also given in Table 6. These records, however, do not represent the entire period of pupation for the second brood, as only a limited number of transforming larvæ were under observation during some seasons.

TABLE 6.—*Length of pupal period of the first and second brood pupæ of the pecan nut case-bearer, Monticello, Fla., 1914, 1915, 1916, and 1917*

Number of individuals	Date of pupation	Date of emergence	Days as pupa
1914—FIRST BROOD			
1	June 9	June 19	10
1	June 10	June 22	12
1	June 12	June 21	9
2	do	June 23	11
1	June 13	June 25	12
5	June 15	June 24	9
1	do	June 26	11
3	June 16	June 27	11
4	June 17	do	10
1	do	June 28	11
1	June 18	do	10
1	June 19	June 29	10
Average for 22 individuals			10. 23
1914—SECOND BROOD			
1	July 13	July 23	10
1	do	July 24	11
2	do	July 25	12
1	July 14	July 24	10
2	do	July 25	11
3	do	July 26	12
2	July 15	do	11
2	do	July 27	12
1	July 16	do	11
1	do	July 28	12
4	July 18	do	10
1	July 19	July 29	10
1	July 20	do	9
1	do	July 30	10
3	do	July 31	11
2	July 21	do	10
1	July 23	Aug. 2	10
1	do	Aug. 3	11
1	July 27	Aug. 7	11
1	July 28	Aug. 8	11
1	July 29	Aug. 9	11
1	do	Aug. 11	13
1	Aug. 3	Aug. 13	10
1	Aug. 5	Aug. 16	11
1	do	Aug. 17	12
1	Aug. 12	Aug. 24	12
1	Aug. 13	Aug. 26	13
Average for 39 individuals			11
1915—SECOND BROOD			
1	July 25	Aug. 3	9
1	do	Aug. 4	10
1	July 26	Aug. 5	10
2	July 31	Aug. 10	10
3	do	Aug. 11	11
4	do	Aug. 12	12
1	do	Aug. 13	13
4	Aug. 1	Aug. 12	11
2	do	Aug. 13	12
6	Aug. 2	do	11
1	do	Aug. 14	12
1	Aug. 3	Aug. 15	12
2	Aug. 4	Aug. 13	9
3	do	Aug. 14	10
Average for 32 individuals			10. 91
1916—FIRST BROOD			
1	June 5	June 17	12
1	June 7	June 18	11
1	do	June 19	12
1916—FIRST BROOD—Continued			
1	June 8	do	11
2	June 9	do	10
1	do	June 20	11
1	June 11	June 22	11
1	June 17	June 28	11
1	do	June 30	13
1	June 18	do	12
2	do	July 1	13
1	June 19	July 2	13
1	June 20	July 3	13
2	June 21	do	12
1	June 24	July 4	10
1	do	July 5	11
1	June 26	July 7	11
1	do	July 8	12
1	June 27	do	11
1	June 28	July 9	11
1	June 29	July 11	12
Average for 24 individuals			11. 58
1916—SECOND BROOD			
2	Aug. 8	Aug. 17	9
2	do	Aug. 18	10
2	do	Aug. 19	11
1	Aug. 9	do	10
1	Aug. 10	Aug. 20	10
1	Aug. 15	Aug. 24	9
1	do	Aug. 26	11
1	Aug. 17	Aug. 28	11
Average for 11 individuals			10. 09
1917—FIRST BROOD			
1	June 2	June 13	11
1	June 3	June 14	11
1	June 7	June 18	11
1	June 8	June 21	13
3	June 9	do	12
2	June 12	June 24	12
1	do	June 25	13
2	June 13	June 26	13
3	June 14	do	12
1	do	June 27	13
1	June 15	do	12
1	do	June 28	13
1	June 16	do	12
1	June 17	do	11
2	do	June 29	12
1	June 18	do	11
1	June 20	July 2	12
1	June 21	do	11
1	June 23	July 4	11
2	June 25	July 6	11
2	do	July 7	12
1	June 29	July 11	12
1	July 2	July 12	10
Average for 32 individuals			11. 84
1917—SECOND BROOD			
2	Aug. 1	Aug. 13	12
2	Aug. 2	Aug. 14	12
1	Aug. 14	Aug. 27	13
1	Aug. 19	Aug. 30	11
Average for 6 individuals			12

The data on the length of the pupal period of the first-brood pupæ for 1915 are incomplete, but in the case of the few individuals under observation the pupal period lasted from 10 to 11 days.

NUMBER OF GENERATIONS

Life-history studies have shown that under normal conditions the pecan nut case-bearer has three generations annually, at Monticello, Fla., and that it passes the winter in the immature larva stage of the third generation. These third-brood larvæ after feeding sparingly for a few weeks migrate during the latter part of September or the first part of October to the buds, where they construct small, compactly woven hibernacula, in which they hibernate until the following spring, when the buds on pecan trees are beginning to open. In confinement it may be possible for the pecan nut case-bearer to have four generations.

PARASITIC ENEMIES

The writer has on several occasions reared a number of parasitic insects from the larvæ and pupæ of the pecan nut case-bearer as follows: *Exorista* (*Nemorilla*) *pyste* Walk.,[3] *Habrobracon variabilis* Cush.,[4] *Calliephialtes grapholithae* Cress.,[4] *Cremastus* (*Zaleptopygus*) sp.,[5] and *Angitia* sp.[4] The most effective parasite is the tachinid fly *Exorista pyste* Walk., which was reared in large numbers from the larvæ and pupæ, and is no doubt a very important factor in the natural control of this pest. The braconid *Habrobracon variabilis* also was frequently bred, and is perhaps second in importance among the parasites of the pecan nut case-bearer.

CONTROL MEASURES

Investigations so far conducted show that the best method of control against the pecan nut case-bearer is spraying with arsenate of lead.[6] The arsenate should be used at the rate of 1 pound of the powdered form, or 2 pounds of the paste form, to each 50 gallons of water, to which should be added the milk of lime from 3 pounds of slaked lime. The addition of lime is necessary to prevent arsenical injury to the foliage and nuts. Three applications will be required and should be at the following periods:

1. Soon after the nuts have set, at which time they are about the size of garden peas.
2. One week or 10 days later.
3. From four to five weeks after the second application.

The date for the first application at Monticello, Fla., during the season of 1915 was found to be May 15, and in 1916 it was May 12. The time of spraying, however, will vary somewhat according to latitude and the character of the season. The first and second applications are the most important in the control of the pecan nut case-bearer, as most of the damage to the nuts is usually caused by the larvæ of the first generation. Since only a small portion of the nut crop is attacked by the second-brood larvæ, it is suggested that if growers desire to reduce spraying of their orchards to a minimum the last application be omitted, but that the first and second applications be made very thorough.

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[3] Determined by W. R. Walton.

[4] Determined by R. A. Cushman.

[5] Determined by R. A. Cushman. The genus Cremastus now embraces the old genus Zaleptopygus.

[6] In connection with life-history investigations, spraying experiments were conducted during 1915 and 1916, the results of which were reported in detail in Farmers' Bulletin 843 of the United States Department of Agriculture, pages 6 to 9. Further spraying experiments were begun in the spring of 1917, but could not be successfully carried out on account of the mildness of the infestation of the insect in the orchard selected for this work.

It is realized that the control recommendations given for this insect are not altogether satisfactory, but in the light of present knowledge they are the best that can be offered. Further detailed investigations are now being made to determine, if possible, a more effective method of controlling the pecan nut case-bearer, as well as other pecan insects of economic importance. Some time must necessarily elapse before reporting on these investigations, and in the meanwhile pecan growers are urged to use the control measures recommended.

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